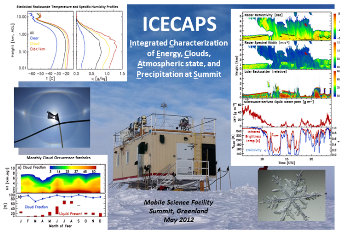
High and Dry - Probing Greenland's Atmosphere and Clouds

Research Highlight

High atop the Greenland Ice Sheet, cloudy skies portend warmer temperatures and higher winds. These clouds alter the surface energy budget, diminish the strong near-surface atmospheric stability, and precipitate ice crystal to the surface. Together these processes comprise the focus of the Integrated Characterization of Energy, Clouds, Atmospheric state, and Precipitation at Summit (ICECAPS) project that has been underway since summer 2010 at Summit, Greenland (72.6 N, 38.4 W, 3250 m). Exciting initial results are rolling out, providing the first detailed look at cloud and atmosphere properties and processes over the Greenland Ice Sheet. The action observed by the extensive, ground-based instrument suite can be followed via daily imagery available at www.esrl.noaa.gov/psd/arctic/observatories/summit.

Playing key roles in the U.S. Arctic Observing Network (AON) and the International Arctic Systems for Observing the Atmosphere (IASOA) network, ICECAPS is a collaborative project between the Universities of Colorado, Idaho, and Wisconsin, with substantial support from the National Science Foundation, the National Oceanic and Atmospheric Administration, the Department of Energy, and Environment Canada. Principal investigators Von Walden, Matthew Shupe, David Turner, and Ralf Bennartz lead a large team of field technicians, engineers, graduate students, and collaborators as they endeavor to make year-round measurements of the atmosphere and clouds in the extreme Greenland Ice Sheet environment. The instrument suite, housed in a movable facility, includes highly complementary observational perspectives from microwave and infrared radiometers, lidars, radar, ceilometer, sodar, precipitation sensor, and twice-daily radiosonde profiles. Included in the suite are a micropulse lidar and ceilometer from the DOE's Atmospheric Radiation Measurement Climate Research Facility. These measurements can be jointly used to characterize the diurnal and seasonal variability of atmospheric structure, cloud microphysical and radiative properties, and precipitation. ICECAPS provides a new and unique observational examination of these climatically important aspects of the ice sheet environment and will offer important context for ongoing precipitation and surface energy budget measurements at the site.

At Summit, the atmosphere is extremely dry and cold with strong near-surface static stability predominating throughout the year, particularly in winter. This low-level thermodynamic structure, coupled with frequent moisture inversions, conveys the importance of advection for local cloud and precipitation formation. Cloud liquid water is observed in all months of the year, even in the particularly cold and dry winter, while annual cycle observations indicate that the largest atmospheric moisture amounts, cloud water contents, and snowfall occur in summer and under southwesterly flow. Atmospheric ice crystals, or diamond dust, readily form as advecting air masses cool over the ice sheet, leading to outstanding optical displays. Surprisingly, many of the basic structural properties of clouds observed at Summit, and particularly the low-level stratiform clouds, are very similar to their counterparts in other Arctic regions in spite of the unique environment encountered on top of the ice sheet. The ICECAPS observations and accompanying analyses will be used to improve the understanding of key cloud–atmosphere processes and the manner in which they interact with the ice sheet surface. Furthermore, they will facilitate model evaluation and development in this data-sparse but environmentally unique region.



ICECAPS examples, clockwise from top left: (1) Mean profiles of atmospheric temperature and specific humidity from radiosondes for different cloud states. (2) Example observations from an autumn case. (3) Dendrite ice crystal photograph, showing small frozen rime droplets. (4) Monthly statistics of cloud and cloud liquid water occurrence. (5) Optical display resulting from oriented ice crystals in the atmosphere. Background: the Mobile Science Facility, home to ICECAPS observational instruments.

Reference(s)

Shupe MD, DD Turner, VP Walden, R Bennartz, M Cadeddu, B Castellani, C Cox, D Hudak, M Kulie, N Miller, RR Neely, III, W Neff, and PM Rowe. 2013. "High and Dry: New observations of tropospheric and cloud properties above the Greenland Ice Sheet." Bulletin of the American Meteorological Society, 94, 169-186.

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Working Group(s)
Cloud Life Cycle